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Short Communication

Additional records of freshwater fishes from Timor-Leste, with notes on the fish fauna of the unique land-locked Irasiquero River system

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Timor is the largest of the Lesser Sunda Islands, which comprise the south-eastern part of the Indonesian Archipelago (Audley-Charles 1968). It is a non-volcanic island situated in the Outer Banda Arc which lies between the Sahul Shelf of Australia and the Sunda Shelf of South-east Asia (White *et al.* 2006). Timor-Leste (East Timor) occupies the eastern half of the island of Timor, encompassing an area of 14 875 km^2 (White *et al.* 2006). This note focuses on the easternmost part of Timor-Leste, east of the town of Lospalos, including the newly created Nino Konis Santana National Park, Timor-Leste's first national park. For a description of the climate, geology and geomorphology of the area, see White *et al.* (2006).

To date, 56 species of fishes have been reported from the fresh waters of Timor-Leste (Larson and Pidgeon 2004), with an unknown number of other species records possibly included in previous literature that did not distinguish East from West Timor (e.g. Reuvens 1895; Weber and de Beaufort 1912, 1922; Allen 1991; Monk *et al.* 1997). Additional collaborative survey work by the University of Western Australia and the Environmental Research Institute of the Supervising Scientist (ERISS) in September 2006 obtained new records of fishes from a range of localities in the north-east of the country. A brief description of site localities sampled for fishes is provided in Table 1 with a summary of fish species collected at each site in Table 2. New records, indicated by an asterisk in Table 2, are annotated individually in this document.

IRASIQUERO RIVER SYSTEM

The waters of Lake Iralalaro and the Irasiquero River form a unique closed aquatic system (White *et al.* 2006), with over 65% of the catchment within Nino Konis Santana National Park. The system is home to the endemic hardyhead *Craterocephalus laisapi* Larson, Ivantsoff and Crowley. To date, this species is only known from the Irasiquero system from 13 specimens. It was collected at sites on the Iralalaro Lake outflow (Fig. 1) and along the length of the Irasiquero River (Fig. 2), including locations of both low and strong flow. However, due to the difficulty in sampling, the data available on this species are insufficient to adequately identify preferred habitat. It was captured from habitats with languid flow in the lake section of the river (Fig. 1), but predominantly from riffle zones, using back-pack electrofishing units. The dominance in riffle habitat, however, could be an artefact of the increased sampling efficiency in these areas and the inability to sample deeper, often fast-flowing waters (which are inhabited by a land-locked population of the estuarine crocodile *Crocodylus porosus*).

The Irasiquero system has only one other native species recorded, the mangrove goby *Mugilogobius cavifrons* Weber. This is a common amphidromous species known from southern Japan, Taiwan, the Philippines, Micronesia, Indonesia and islands off Papua New Guinea (Larson 2001). The land-locked Irasiquero specimens fit the current description of *M. cavifrons* but exceed the reported standard length. The success of this species in the Irasiquero indicates plasticity in its reproductive biology. Currently, *M. cavifrons* has not been recorded from other springs or rivers in Timor-Leste (Table 2; Larson and Pidgeon 2004). This could be due to a lack of suitable habitat or insufficient sampling effort to date.

The closed Irasiquero River system has an absence of catadromous and amphidromous species from the families

Anguillidae, Eleotridae and Gobiidae which have been recorded in other rivers and springs in Timor-Leste (Table 2; Larson and Pidgeon 2004). The absence of these taxa demonstrates the land-locked nature of the Irasiquero and indicates that the resident populations of *Craterocephalus laisapi* and *Mugilogobius cavifrons* have adapted to survive in these conditions. Given that the hardyhead appears to be endemic to this closed system, it would not be surprising if the *Mugilogobius* is found to be genetically distinct.

Fig. 1. Iralalaro Lake outflow, habitat of the endemic hardyhead, *Craterocephalus laisapi*, just downstream of Iralaluru Lake. The water here is dark and tannin-stained, with low dissolved oxygen, but abundant aquatic plants. Photograph by Alistair Cameron.

Fig. 2. Irasiquero River lower reach, habitat of the endemic hardyhead, *Craterocephalus laisapi*. The water here flows clear over limestone bedrock. Photograph by Jessica Lynas.

The populations of *C. laisapi* and isolated population of *M. cavifrons* in the Irasiquero have, to date, survived the introduction of four non-native species: *Gambusia affinis* (Baird and Girard), *Aplocheilus panchax* (Hamilton), *Clarias gariepinus* (Burchell) and *Oreochromis mossambica* (Peters). Two of the introduced species were either captured (*A. panchax*) or observed (*O. mossambica*) along the full length of the Irasiquero River. The remaining two species (*G. affinis* and *C. gariepinus*) were captured mostly in the upper Irasiquero where water velocity was lower. Both *O. mossambica* and *C. gariepinus* are predatory, and presumably include in their diet both native species, as well as other introduced species. Because of limited historical data it is not possible to determine the impact these introduced species have already had upon the native fish fauna.

Clarias gariepinus and *O. mossambica* were presumably intentionally introduced in the Irasiquero system as a source of food for local villagers. *Oreochromis mossambica* has not been recorded from any other location in Timor-Leste (Table 2; Larson and Pidgeon 2004). It is a very resilient and aggressive fish species which can occupy fresh water, brackish and even marine (lagoon and atoll) habitats (Allen *et al.* 2002). If *O. mossambica* is relocated into any other river or spring (outside Nino Konis National Park) it has the potential to invade other systems due to its ability to sustain marine populations (Lobel 1980; Nelson and Eldredge 1991).

OTHER RIVERS AND SPRINGS

The other rivers and springs sampled in Timor-Leste in September 2006 were located on the north and south coasts, which have differing monsoonal conditions, the north coast being dryer (White *et al.* 2006). Sites on the north coast (Ira Ono, Lutu Ira and Came Ira springs) were severely modified and often impounded to provide drinking water supplies, and to irrigate gardens and plantations using a network of small diversion channels. As a result, the water did not reach the sea, at least when sites were sampled in September 2006. Introduced fish species comprised the entire fish community at these three sites (Table 2). In contrast, sites on the south coast (primarily located in the new Nino Konis Santana National Park) remained relatively unmodified and, seasonally at least, are connected to the ocean. Sites from the south coast only contained native species that have a marine stage in their life cycle (Table 2). They include the eight new records discussed below.

It is likely that further surveys in Timor-Leste will reveal additional fish species, given that the last two surveys have identified 32 new records in total, 24 in October 2003 (Larson and Pidgeon 2004) and eight from the survey in September 2006. The juvenile *Microphis* obtained during the present survey does not appear to be *M. retzii* (Bleeker) (known from Timor-Leste) and may possibly be *M. mento* (Bleeker); an adult specimen is required for verification. The record of *Anguilla reinhardtii* Steindachner by Larson

Table 1. Descriptions of Timor-Leste freshwater fish sampling sites (electrofishing and dipnets).

Region	Site	General description
Closed Irasiquero River System	Irasiquero Lake outflow	Just downstream of where river emerges from a lentic wetland waterbody (Iralalaro); slow-flowing, darkly coloured, tannin-stained waters; silty organic sediments; abundant macrophytes. Three sites sampled in this habitat (8°26.84'S,127°9.24'E; 8°26.92'S,127°9.36'E; 8°27.09'S,127°9.53'E). The presence of crocodiles and deep water made sites difficult to sample.
	Irasiquero River mid reaches	Clear groundwater-fed waters. Reach varies from riffle and pool sequence to a fast-flowing channel. Typically bedrock (limestone)/pebble channel; abundant macrophytes amongst channel; areas of woody debris and over hanging vegetation. Three sites sampled along the river length (8°27.67'S,127°9.87'E; 8°28.23'S,127°9.96'E; 8°28.35'S,127°10.15'E). Fast flowing deep water made sampling difficult, crocodile sighted at the most downstream site.
	Irasiquero river lower reaches	Clear groundwater-fed waters; Reach typically channel predominately bedrock (limestone) with boulders/pebble/gravel and sand. Presence of macrophytes varies; algae in areas; areas of woody debris and over hanging vegetation. Three sites sampled along the river length (8°28.37'S,127° 10.05'E; 8°28.54'S,127°10.46'E; 8°28.36'S,127°10.47'E). Fast flowing deep water made sampling difficult.
Other Rivers	Tehino River	Downstream of bridge; seasonally flowing with very low, dry season flow comprising gravel runs; gravel/pebble substrate with some detritus and algal cover; no macrophytes or overhanging riparian vegetation. (8°35.57'S,126°59.95'E). Site sampled in 2003 and 2006.
	Arapvaco River	(Name meaning: Track of the buffalo). Cobble habitat; silt sediment; no overhanging vegetation or macrophytes (8°32.97'S,127°7.42'E).
	Lalalapa River	One of the main rivers draining the southern slope of the Paitchau Mountain range, sampled approx. 3 km upstream of the Timor Sea; rocky/cobble habitat; riffle/pool sequences; crocodile seen (8°35.61'S,127°4.86'E).
	Ira Bere River	(Name meaning: Big water). Cobble habitat with silt sediment and algal cover; no overhanging vegetation or macrophytes; crocodile seen (8°44.94'S,126°43.94'E).
Springs, South Coast	Ira Lafai	Cascading limestone/boulder spring; root mats and leaf packs; sampled where water arose from rocks; overhanging riparian vegetation (8°39.42'S,126°57.94'E).
	Tehino	Spring comes out of the ground into a pool/backwater area of the Tehino River; root mats present (8°35.79'S,127°1.79'E).
	Veroruhu	Cascading cobble/boulder spring; root mats and leaf packs, but no trailing vegetation (8°28.98'S,127°12.61'E).
	Han	(Name meaning: To eat). Permanent spring; pools and flow stone along creek; boulder/cobble/ pebble habitat; root mats (8°28.16'S,127°12.90'E).
	Sair Ira	Tumulous/flow-stone pools upstream (8°26.67'S,127°13.71'E).
	Nair Etc	Ira Ina is the name of the actual spring (=mother of water). Spring seep from bank into creek; cobble/boulder stream; root mats (8°24.78'S,127°14.16'E).
	Fa Fa	Large pool below waterfall of calcified material/tufa; water had a green tinge – perhaps due to algae (8°25.56'S,127°14.19'E).
Springs, North Coast	Ira Ono	(Name meaning: Ono = name of the spring owner). Spring arises from a hole in the limestone; root mats present; small pond/weir downstream (8°22.17'S,127°2.22'E).
	Lutu Ira	(Name meaning: Rice/corn grinding bowl made from tree trunk). Spring with several outflow points from rocks into a pool in the middle of the village (Ira Ara) ~ 5-6 km west of Com; used for drinking, washing, irrigation of paddy fields and gardens; root mats from *Ficus*. (8°20.54'S,127°1.15'E).
	Came Ira	Small seep; no root mats; water used for village drinking supply, washing, stock and crops/ plantations (8°23.60'S,127°13.99'E).

and Pidgeon (2004) was apparently the first for the region, as it is elsewhere known from southern New Guinea, New Caledonia and eastern Australia (Smith 1999); this was overlooked by those authors.

NEW RECORDS AND ADDITIONS FOR TIMOR-LESTE

Specimens of all species discussed below are held in the fish collection of the Museum and Art Gallery of the Northern Territory, Darwin.

Ophichthidae

Lamnostoma mindora (Jordan and Richardson). This freshwater snake-eel was previously known from New Guinea and the Philippines (Kottelat *et al.* 1993). It was found at several localities in Timor-Leste (Table 2).

Atherinidae

Craterocephalus laisapi Larson, Ivantsoff and Crowley. Among the species obtained were additional specimens of the recently described endemic atherinid, *Craterocephalus laisapi* (*Craterocephalus* sp. (Larson and Pidgeon 2004)),

Table 2. Fish species recorded at each site including rivers (R) and springs (S) in Timor-Leste. Records include results from September 2006 (+) and supplementary results from October 2003 (!). * New record for Timor-Leste.

	Closed Irasiquero River system			South coast										North coast		
	Irasiquero (R) lake outflow	Irasiquero (R) River – mid	Irasiquero (R) River - lower	Tchino River (R)	Arapvaco River (R)	Lapalapa River (R)	Irabere (R)	Tchino Spring (S)	Veroruhu (S)	Han Spring (S)	Sair Ira (S)	Nair Ete (S)	Fa Fa (S)	Ira lafai (S)	Ira Ono (S)	Lutu Ira (S)	Came Ira (S)
NATIVE																	
Anguillidae																	
Anguilla celebesensis												+					
Anguilla marmorata					+	+		+			+						
Anguilla reinhardtii				!	+												
Ophichthidae																	
*Lamnostoma mindora**						+	+										
Atherinidae																	
Craterocephalus laisapi	+	+	+														
Syngnathidae																	
Microphis sp. (juvenile)							+										
Lutjanidae																	
Lutjanus argentimaculatus					+	+	+										
Lutjanus fuscescens						+											
Kuhliidae																	
Kuhlia marginata				!	+	+											
Kuhlia rupestris						+											
Mugilidae																	
*Liza melinoptera**					+												
Eleotridae																	
Belobranchus belobranchus				+				+					+				
Bunuka gyrinoides				!	+						+						
Eleotris fusca				!	+	+	+	+			+						
Giuris margaritacea						+	+				+			+			
Gobiidae																	
Awaous melanocephalus				+	+		+	+									
Glossogobius celebius							+										
Lentipes sp.				!					+								
Mugilogobius cavifrons	+	!															
*Sicyopterus caeruleus**					+				+			+					
Sicyopterus hageni				+	+		+	+	+	+			+				
Sicyopterus micrurus								+		+							
*Sicyopterus longifolis**				+													
Sicyopterus sp. (juvenile)						+											
*Sicyopus zosterophorum**				+				+				+					
*Stiphodon semoni**				+				+		+							
*Stenogobius blokzeyli**							+										
Rhyacichthyidae																	
*Rhyacichthys aspro**								+									
EXOTIC																	
Clariidae																	
Clarias gariepinus	+	+	+													+	+
Poeciliidae																	
Gambusia affinis	+	+													+		
Poecilia reticulata															+	+	
Andrianichthyidae																	
Aplocheilus panchax	+	+	+														
Cichlidae																	
Oreochromis mossambica	+	+															

increasing the number of known specimens from four to 13 (found only in the Irasiquero River).

Mugilidae

Liza melinoptera (Valenciennes). Several species of mullet are known to penetrate fresh waters; these specimens came from a series of isolated pools in the Arapvaco River, just at the tidal limit about 2 km upstream from the coast.

Gobiidae

Lentipes sp. A single juvenile of this genus was reported from the Tchino River by Larson and Pidgeon (2004). A single adult female was obtained in the 2006 survey from Veroruhu Spring, having a combination of features that do not match any of the described species of *Lentipes*. It is probably undescribed. As species of this genus are often strongly sexually dimorphic, it is hoped that further work will discover an adult male, so that the fish can be more easily identified.

Sicyopterus caeruleus (Lacepède). This species is possibly what Weber and de Beaufort (1912) identified as *S. cynocephalus*. The synonyms for this species are many and there are conflicting opinions as to the correct name (e.g. Watson *et al.* 2000; Sparks and Nelson 2004). We use *S. caeruleus*. It was found at several localities in Timor-Leste (Table 2).

Sicyopterus longifilis de Beaufort. A single specimen was obtained from the Tchino River.

Sicyopus zosterophorum (Bleeker). Adult males and females were obtained from several localities (Table 2).

Stiphodon semoni Weber. It is possible that the single small specimen reported by Larson and Pidgeon (2004) as *Stiphodon cf atratus* is this species. The present specimens (from Tchino River, Tchino Spring and Han Spring) are of a size range that includes adults of both sexes, making identification possible. Taxonomic research is underway on new species related to *S. atratus* by Jeff Johnson and Tony Gill (J. Johnson, Queensland Museum, pers. comm.); these species resemble *S. semoni*.

Stenogobius blokzeyli (Bleeker). This species is only known from the two type specimens (from Bali); both are females in poor condition (Watson 1991). The single Timor-Leste specimen is a small male, with more teeth than previously reported for this species or for *S. zurstrasseni* (Popta), a likely synonym (Watson 1991).

Rhyacichthyidae

Rhyacichthys aspro (Valenciennes). Only one juvenile specimen was found, at Tchino Spring.

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